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Crop Germinative Emergence of Maize (*Zea mays*) and Finger Millet (*Eleusine coracana*) as Affected by Plastic Waste Material

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Plastic waste material continues to present environmental challenges throughout the world. Of greatest concern is their disposal in agricultural soils where they interfere with soil fertility due to its inability to decompose fast. Specifically, the research examined under experimental conditions the crop germinative emergence of (*Zea mays* L.) and finger millet (*Eleusine coracana* (L.) Gaertn) as affected by plastic waste material commonly disposed in urban and rural environments of Kenya. The plastic types were identified by their thickness of 30 microns. The experiment was laid out in a 2 by 1 Randomized Block Design (Latin Square) with two replicates in plots each measuring 1m x 1m. The data collected involved determination of emergence percent cover. The date of planting was noted and records were taken from the day first shoot emergence was observed in controls for 10 days. Percent emergence measurements was done for at least 10 days and this involved taking of vertical photographs of each plot from the day first shoot emergence was observed in controls. Assumptions of normality were found to be satisfactory and the set hypotheses were supported by the results. In the overall, there were significant differences ($P<0.05$) between *E. coracana* planted in soils mixed with 6 microns thick plastic material and the ones planted in controls. The EPC mean

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for the *E. coracana* planted in soils mixed with 30 microns thick plastic material was 25.78%, while controls had 75.58%. There were significant differences (P<0.05) between *Z. mays* in soils mixed with 6 microns thick plastic material and the ones planted in controls. The EPC mean for the *Z. mays* planted in soils mixed with thick plastic material was 41.52%, while that of control groups was 86.18%. In conclusion, there were a significant difference (P<0.05) in effects of 6 microns' thick plastic material on germinative emergence of the two food crops, that is; *E. coracana* and *Z. mays* and hence the study recommends that, plastic waste material of any thickness should be avoided on farmlands where *Z. mays* and *E. coracana* are grown.

Keywords: Vertical photographs; randomized block design; agricultural soils; plastic waste material.

1. INTRODUCTION

Physical presence of materials in soil may present obstruction (impedance) to germinating seeds. Research on obstruction of germinating seeds have largely focused on roots growth unless on shoots and more particularly obstruction by plastics, for instance, soil hardness causes impedance of root growth of cereals such as wheat and barley [1].

The issue of solid waste management and particularly plastic waste is a global challenge, for instance, in 1960, the Ministry of Food and Agriculture in India offered loans to Urban Local Bodies for solid waste management initiatives but up to date very little has been Zahra *et al.,* [2]. Globally, about 100,000 tones of plastic has been found floating in the world's oceans, thus leading to much more problems such as that of affecting aquatic life. It has been noted that none of the European Union legislation has ever addressed the issue of plastic waste in a strategic way [3].

Plastic waste disposal in Kenya remains a big problem especially in towns and urban centers, thus resulting in environmental pollution [4]. Additionally, this has left the country messed with different types of plastic waste all over especially in urban areas as well as farmlands. The most affected sector is agriculture since plastic waste take very long to decompose thus leading to reduced soil fertility besides soil pollution [5]. According to NEMA [6], plastic bags are found to be one of the most serious problems in the environment. Moreover, NEMA points out that, by 2007 over 2,000,000 plastic bags were being produced every year in Nairobi alone. However, in 2008 some of African countries such as Kenya made an effort of imposing a national ban of plastic material of less than 30 microns in thickness although this did not succeed [4]. It was not until 2017 that Kenya government succeeded in banning packaging/carrier bags [7].

Present research on crop management for food security in Kenya and elsewhere is largely focused on good soil quality and water availability as well as crop selection [8]. Soil is a natural body consisting of layers (soil horizons) of mineral constituents of variable thicknesses, which differ from the parent materials in their morphological, physical, chemical, and mineralogical characteristics [9]. Soil needs to have good soil texture and structure, optimum temperatures, oxygen, moisture nutrients as well as microorganisms in order to support the process of plant growth (Raven *et al.,* 2005). According to Zahra *et al.,* [2], they include water, oxygen favorable temperatures among others.

Contaminated or polluted soil and water directly and indirectly affects both plants and animals which in turn affect human health through direct contact with soil or via consumption of crops grown from contaminated soils [10]. This type of contamination mainly arises from anthropogenic activities, for instance, production of plastic material and release to the soils thus leading to soil contamination [8]. With the excessive use of plastics and increasing pressure being placed on capacities available for plastic waste disposal, the need for biodegradable plastics and biodegradation of plastic wastes has assumed increasing importance in the last few years (Kuijer *et al.,* 2010).

Food crop production requires access to land with adequate nutrients, water and good physical structure (Kuijer *et al.,* 2010). The increased use of urban solid waste as fertilizer may cause additional health hazards [11] for instance, in case of Kano in Nigeria, farmers often apply solid waste from tanneries, which not only emits bad odours, but forms an excellent breeding ground for disease vectors [12].

In order to solve the issue of environmental pollution by plastic waste, there is need to support the issue of biodegradable plastics, as defined, by American Society for Testing Materials (ASTM) a biodegradable plastic is a plastic that degrades because of the action of naturally occurring microorganisms such as bacteria among others. Probably these kinds of plastics may be useful in trying to solve the problems brought about by synthetic plastics which are largely released in the environment (Syagga, 2004).

Although manufacturing of biodegradable plastic consumes a lot of energy [3], they would help in reducing most of environmental issues such as soil pollution, killing of aquatic animals like fish and turtle, clogging of water ways and sewerage systems which are contributed by non biodegradable plastics [13]. According to Syagga (2004), compostable plastics can be equally useful in that, they are degraded by microbial activity during decomposition to yield water, carbon dioxide, inorganic compounds and biomass which are not toxic to the environment. Adugna [14], explains that although compost manure have many benefit in soils, it is always important to find out its disadvantages since they may hinder crop germination.

Manufacturers need to ensure that plastic bags are made of materials that can be recycled more easily (ISO, 2000). Distributors, retailers and also manufacturers of plastic carrier bags are required to apply environmental policies for the management and disposal of plastic bags [3]. In this regard, in February 2005, a report issued by the Kenyan government, the United Nations Environment Programme (UNEP) and the Kenya Institute for Public Policy Research and Analysis recommended one time that, Kenya ought to fight against plastic proliferation [15].

1.2 Problem Statement

Over history, plastic material has been known to cause a variety of environmental problems. In these world countries, uncontrolled disposal of plastic waste is increasingly finding its way into farmlands in peri-urban and rural areas. Polythene bags are not biodegradable; therefore it has been a serious environmental problem (Holt, 2000). In addition, both flora and fauna has been affected for example, aquatic animals have died especially when they mistake these polythene waste with food. According to United Nations Environment Programme (2018), it is explained that the plans towards banning on single-use plastics could be a very comprehensive policies to help reduce plastic waste generation and hence leading to a good environment. For example, packaging plastic bags ban in Kenya has contributed towards manufacturing and sale of more durable carrier bags that can be reused several times thus reducing plastic production [7].

Soils have become infertile and poor drainage has emerged, thus making it unfit for crop growth. Impedance of root development by factors such as soil hardness and density are relatively more researched than on shoots [16]. A lot of plastic bags have been disposed into the environment and have caused a serious soil and water pollution. Presence of physical materials in the soil such as plastics may have the same effect as that of soil hardness. In particular, research on the effect of obstruction by plastic on germinative emergence of *Eleusine coracana* (G) and *Zea mays* (L) is scarce in Kenya; hence research on this area was required.

1.3 Research Questions

The research was guided by the following questions:

1. How does 6 microns thick plastic material in the soil affect germinative emergence of *Z. mays* and *E. coracana* ?
2. What is the relationship between germinative emergence and the thickness of plastic materials?

1.3 Objectives of the Study

The broad objective of this study was to investigate the effect of plastic waste material on germinative emergence of *E. coracana* and *Z. mays*. The specific objectives of the study were:

1. To analyze the effect of 6 microns thick plastic material in the soil on germinative emergence of *Z. mays* and *E. coracana*.
2. To determine the relationship between germinative emergence and the thickness of plastic materials

1.4 Hypotheses

H_1*:* Plastic materials of 6 microns thick in the soil reduce germinative emergence of *Z. mays* and *E. coracana.*

H_2: There is a relationship between germinative emergence and the thickness of plastic materials

1.5 Significance of the Study

The information from the study will be used by other scholars as literature review. Raising awareness about plastic waste to farmers, as well as availing information to agriculturalists and policy makers in order to ensure that soil does not get polluted by plastics, and also providing guidelines on the formation of strategies in regard to plastic waste management.

1.6 Definition of Terms

1.6.1 Impedance

It is the obstruction of seeds as it tries to emerge from the soil during the process of germination.

1.6.2 Germinative emergence

The ability of shoot to get out of the soil during germination process.

1.6.3 Thick plastic

The kind of polyethylene (LLDE) which range in thickness of about 6 microns.

1.6.4 Pollution

Presence of matter (plastic papers of different thickness) whose nature, location, or quantity directly or indirectly alters processes of seeds germination and causes (or has the potential to cause) damage to the condition, health, safety, or welfare of plants.

1.6.5 Non polluted soil

This refers to the soil with no plastic materials in the study

1.6.6 Biodegradation

Series of processes by which living organisms break down chemicals into less toxic components to the environment.

1.6.7 Bioplastic

A term used for natural polymers that are made without petrochemicals.

1.6.8 Biodiversity

Is the degree of variation of life forms within a given species, ecosystem, biome, or an entire planet.

1.6.9 Environment

The sum total of all surroundings of a living organism, including natural forces and other living things.

1.6.10 Waste management

The collection, transport, processing or disposal, managing and monitoring of waste materials. The term usually relates to materials produced by human activity, and the process is generally undertaken to reduce their effect on health, the environment or aesthetics.

2. MATERIALS AND METHODS

2.1 Study Design

The broad objective of this study was to investigate the effect of plastic waste material on germinative emergence of *E. coracana* and *Z. mays*. Specific objectives of the study included; analyzing the effect of 6 microns thick plastic material in the soil on germinative emergence of *E. coracana* and *Z. mays*. The objective was achieved through comparison of food crops planted in areas with treatments and those without. The other objective was determining the relationship between germinative emergence and the thickness of plastic materials which was achieved by comparing the germinative emergence trends of the two food crops with the treatments and those of control as well as comparing the overall emergence percentage cover of the food crops planted in areas with treatments and those without.

The experiments were laid out as Randomized Block Design with a 2 by 1 factorial design with three replicates during the initial stages of the set up, as shown in Figure 1. Two by one factorial design with three replicates was used mainly because it is suitable for experiments as it was able to combine multiple variables which are involved in the same factorial experiment (Trochim, 2006).

2.1.1 Variables

The study involved independent variables such as: plastic materials (6 microns thick plastic materials), and dependent variable such as germinative emergence of *E. coracana* and *Z. mays* and soil without plastic waste. These variables were determined to give out results.

2.1.2 Materials

E. coracana and *Z. mays* seeds were used, as they are fast growing in comparison to other crop types. In this study, Pioneer *Z. mays* and Lingmethang Kongfu-1 (ACC-3459) *E. coracana* varieties were planted; thick plastic materials were used as treatments. The plastic material referred to as “thick” in this study was 6 microns in thickness. These are the kind of plastics that are commonly used for packaging and wrapping snacks. The thickness was determined using a digital caliper which is designed to measure plastic paper thickness. Other materials involved were: weighing machine to determine the weight of the plastic waste material to be used, plastic material sourced from Kenyatta University dump sites and a tape measure for marking the site and plots. Soil was sampled and collected using zigzag method of soil collection and tested for N (0.82mg/kg), P (4.2 mg/kg), K (1.20 mg/kg), and pH (5.96).

Table1. Randomized Block Design (Latin Square)

R \ B	A	B	C	D
U	M	M_l	F	F_l
V	M_l	F	F_l	M
W	F	F_l	M	M_l
X	F_l	M_l	F	M
Y	F	F_l	M	M_l

KEYB Blocks, R Rows, M, Z. mays (Control), M_l Z. mays planted in soil mixed with thick plastic material, F E. coracana (Control) F_l, E. coracana planted in soil mixed with thick plastic material

Actual photo ***Photo mosaic***

(a) Vertical photograph of a bare plot and its resulting colour mosaic (as shown by the arrow)
(b) Vertical

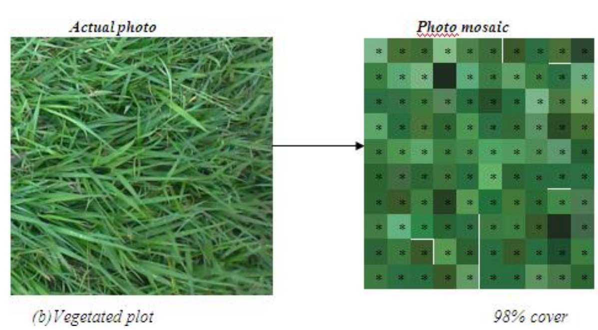


Plate 1. Vertical photograph of plots and a resulting colour mosaic (the stars in the plate were meant to identify green tiles)

2.1.3 Methods

Randomized Block Design was used to lay down the experiment as illustrated in Figure 1. According to Hinkelman and Kempthorne (2008), Randomized Block Design ensures that each treatment appears once in every column and row, that is; rows and columns are quadrilateral to treatments, and constant variances are taken care of in experiments. Each level in the experiment appears the same number of times thus ensuring unbiased estimation of main effects. It is mainly used for elimination of two nuisance sources.

2.2 Site Preparation and Planting

The site was selected and cleared using a panga and was dug using a hoe. It was dug two times at an interval of one week using a hoe and left for one and half week to allow the vegetation to dry up completely. It was harrowed for the third time, and this was followed by soil leveling using a rake to obtain a fine tilth for planting. Each of twenty five plots was measured 1m x 1m, marked and boundary alignment was set using cartons whose bottoms were removed. This was to control soil erosion and also to prevent the broadcast *E. coracana* seeds from being carried away by water.

400g of shredded plastics were applied to each of the other 15 plots and mixed together with the soil prior to planting. *E. coracana* seeds were broadcast. No plastic materials were applied to the remaining 10 plots hence were used as controls. The depth of planting depended on the seed size, *Z. mays* seeds were planted at a depth of approximately 6cm and 15cm between and within rows while *E. coracana* seeds were planted by broadcasting method. In this study, pioneer *Z. mays* and Lingmethang *E. coracana* varieties were used.

2.3 Data Collection Procedure

Data were collected from the first day of shoot emergence by taking photographs. Photographs of each of 25 plots were taken by steadily holding the camera vertically over the plot at a vertical height of 1m, with the centre of the camera frame at the centre of the plot. Shadow falling on the plot was avoided every time photograph was taken. All photographs for each observation of every plot were taken on the same day. This was repeated daily for 10 consecutive days adding up to 250 photographs. Emergence percentage cover (EPC) was determined by use of Adobe™ Illustrator CS6 ® software; a software which was able to give analyses of photographs taken.

2.4 Recording of Emergence Percentage Cover

The data collected involved measuring emergence cover. The date of planting (DOP) was noted and given a period for seeds to germinate, this was about three to five days. Data on seedlings emergence was collected on daily basis for 10 days after which emergence percentage cover was recorded for those ten days.

2.5 Determination of Emergence Percentage Cover

Quadrats are traditionally used to estimate vegetative cover; for this experiment 1m^2 quadrat divided into 100 squares could have been suitable. But a relatively more accurate method was to take photos of emerging vegetation (seedlings) and use computer software to concentrate green color into tiles in a 10 by10 mosaics. For this determination Adobe™ Illustrator CS6 ® software was used. Each photo was uploaded on the software blank page, and then converted into color mosaic tiles on 10 by10 dimensions to give 100 mosaics. Distinct green shades (tiles) formed corresponded to the color of the germinated seedlings thus becoming the emergence percentage cover.

For comparative purposes, some of the pictures ‘a’ and ‘b’ (for bare and vegetated grounds respectively) were aligned with resultant conversion to mosaic tiles as illustrated in plate 1. However, these were used as trials prior to experiment.

2.6 Data Presentation

The analyzed data were presented using graphs and tables that seemed to be useful in carrying out comparisons in various variables in data which were collected.

2.7 Data Analyses

The primary data obtained that is; the comparative emergence cover and the extent of shoot obstruction as they emerged from the soil were analyzed for significance (ANOVA; $p \leq 0.05$)

using Statistical Package for Social Sciences (SPSS) Version 17. Specifically, the data was analyzed by comparing their means using one-way ANOVA and F- test was used to test significance of the results. The data analyzed were then presented in tables and graphs.

The photographs uploaded on the software and converted into colour mosaic tiles on 100 tiled squares (mosaic) were then analyzed by use of values of each mosaic. Plate 2 and 3 show sets of photographs and their resulting colour mosaic tiles; for 1st and the 10th day for *E. coracana* which of each is shown by an arrow. This was done to every plot whose photographs were taken for 10 days. For instance, the figures with percentages under each photograph are emergence percentage cover of the plot shown. Stars (*) were used to mark green tiles for easier counting

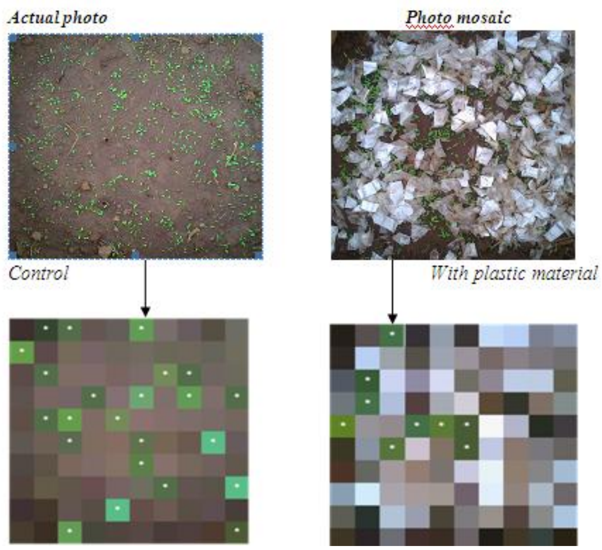


Plate 2. Determination of Percentage Emergence cover.
23% cover (Control) 9% cover (with plastic material)
Plate 2: e. coracana in control and in thin plastics (day 1)
(The stars (*) in the plates were meant to identify green tiles)

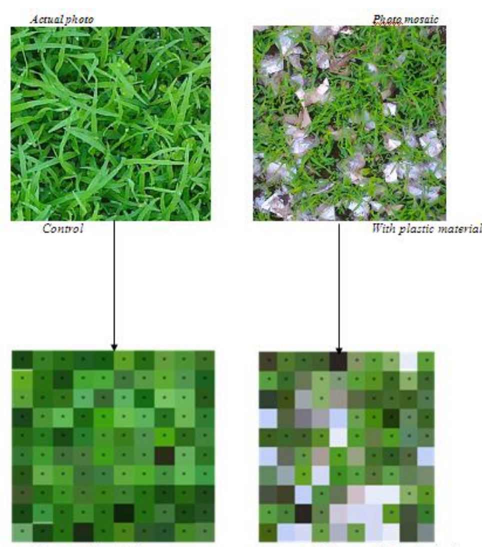


Plate 3. *E. Coracana* in Control and in Thin Plastics (Day 10)
(The stars in the plates were meant to identify green tiles)

3. RESULTS AND DISCUSSIONS

This chapter presents the results obtained from the experiment as described in chapter three. The chapter focuses on the research findings on the crop germinative emergence of *Z. mays* and *E. coracana* as affected by plastic waste material.

3.1 Effect of 6 Microns Thick Plastic Material in The Soil on Germinative Emergence of *Z. Mays* And *E. Coracana*

The study revealed that, the effect of plastic material in soil on GE of *Z. mays* and *E. coracana* varied throughout the study period. From the result, it was revealed that from the first to the fifth day of the study, germinative emergence of *Z. mays* and *E. coracana* were significantly affected by plastic material (p-values: 0.002, 0.000, 0.005, 0.023 and 0.43 for 1st, 2nd, 3rd, 4th and 5th days respectively for *Z. mays* and in case of *E. coracana* p-values were 0.041, 0.001, 0.001, 0.001 and 0.000 for 1st, 2nd, 3rd, 4th and 5th days respectively). However, from the first to the third day germinative emergence of *Z. mays* were more affected than on the fourth and fifth days. *E. coracana* was less affected on the first day, however from the second to the fifth day of the experiment its germinative emergence was significantly affected by plastic material as shown in Table 2.

From the result in Table 2, it was observed that on the 6th and 7th day of the study, germinative emergence of *E. coracana* and *Z. mays* were significantly affected (p-values: 0.026 and 0.028 for 6th and 7th day and 0.000 and 0.000 for 6th and 7th day in *Z. mays* and *E. coracana* respectively).

It was also observed that during the last three days (8th, 9th and 10th days) of the study, germinative emergence of *Z. mays* were not significantly affected (p-values: 0.968, 1.000 and 1.000 for 8th, 9th and 10th days respectively), while that of *E. coracana* was significantly affected (p-values: 0.042, 0.001 and 0.011 for 8th, 9th and 10th days respectively). This was illustrated in Table 2.

Probably this was due to smaller seeds size of *E. coracana* and so plastics covered most of its seeds thereby leading to improper water infiltration and absorption which in turn reduced germinative emergence of the *E. coracana* in the study. As stated earlier by Naylor (1980), small seeds produce weak shoot like in the case of *E. coracana* which were overturned by bulkiness of thick plastics. This was probably the reason as to why germinative emergence of *E. coracana* with treatments was more affected by thick plastic material than those in controls during the initial days of the experiment.

Plastic material in the soil probably brought about water stagnation as a result of their impermeability which later on encouraged poor soil aeration. This in turn adversely affected germinative emergence of *Z. mays* and *E. coracana. Z. mays* have relatively bigger seeds and may be seeds were partly or not covered by thick plastics thus leading to less interference as far as water absorption is concern. This therefore led to a reduced effect.

Table 2. Emergence Percentage Cover mean of *Z. mays* and *E. coracana* during the ten days after emergence (in plastic material)

Days	*Z. mays*	*Control*	*±SE*	*Sig*	*E. coracana*	*Control*	*±SE*	*Sig*
1	2.83	12.17	±1.06*	0.002	12.50	15.17	±1.06*	0.041
2	10.08	20.83	±1.42*	0.000	14.67	23.33	±1.42*	0.001
3	13.90	28.33	±2.75*	0.005	17.50	27.83	±2.75*	0.001
4	34.83	42.33	±4.34*	0.023	18.17	29.00	±4.34*	0.001
5	57.17	65.17	±5.91*	0.043	19.33	38.67	±9.91*	0.000
6	63.50	71.00	±7.20*	0.026	25.83	46.33	±7.20*	0.000
7	64.00	81.00	±7.26*	0.028	28.50	49.50	±7.26*	0.000
8	78.98	85.17	±6.51ns	0.968	45.91	61.33	±6.51*	0.042
9	82.00	89.83	±5.82ns	1.000	62.96	72.17	±5.82*	0.001
10	84.97	91.17	±5.15ns	1.000	74.97	86.17	±5.15*	0.011

*ns: not significant and *: p≤ 0.05*

Soil needs to have about twenty five percent of water and twenty five percent of air so that the process of seed germination can be successfully supported [17]. From this point of view, these percentages probably reduced due to presence of plastics in the soil to a level that reduced the rate of germination as well as minimized germinative emergence thus leading to lower EPC of *Z. mays* and *E. coracana.*

The findings corroborate the concerns expressed by Gautam *et al.,* [12], all of whom state that seed germination cannot take place in absence or in insufficient of water and oxygen. From their studies they found out that due to lack of moisture in the soil, *V. faba* and *Z. mays* seeds failed to germinate. This could be the same case that germinative emergence of the two food crops in the experiment was affected.

From the result, the continuous decrease in effect on germinative emergence of *Z. mays* probably was due to their stronger shoots. They produced stronger shoots that enabled them to go through the soil mixed with thick plastics and therefore were not significantly affected on the last few days. The continuous decrease in effect was accompanied by reduced rate of EPC. Considerably during these last three days (refer table 2), this was probably due to the fact that all seeds had already germinated. In addition, shoots of *Z. mays* continued gaining more strength which enabled them to go through soils with thick plastics. This therefore agreed with the findings of Andrews *et al.,* (1997), that shoot of any plants get more strength as is it grows due to increased cell division.

Although *E. coracana* planted in the soil mixed with plastics showed reduced effect during these last three days (8^{th},9^{th} and 10^{th} days) as well, this effect was observed to be significant. This could be due to the fact that *E. coracana* whose seeds are small produced weak shoots which were continuously overcome by plastics in the soil. Additionally, *E. coracana* must have been previously experienced water scarcity due to hindrance by plastics which in turn affected their metabolic activities thus reducing their germinative emergence.

Baker [18], states that finger millet seeds would take three to five days while maize would take an average of about eight days to germinate and emerge out of the soil. The reduced significance difference during the last three days of the study (day eight, nine and ten), could be due to the fact that most of the seeds had completely germination and hence no more seeds germination ware taking place at the moment.

3.2 The Relationship between Germinative Emergence and the thickness of Plastic Materials

The study revealed that throughout the study period, there occurred a lower percentage crop ground cover trend of *Z. mays* in soils with treatments in comparison to that which did not have. Based on this observation, plastic material in the soil really obstructed *Z. mays* seeds germination thus leading to reduced percentage crop ground cover. This was illustrated in Fig. 1.

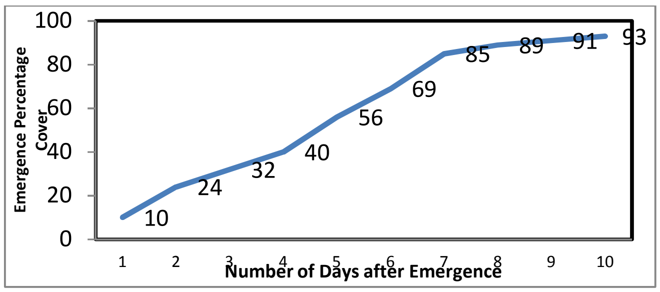
From Fig. 2, it was observed that throughout the study time, there was a lower percentage crop ground cover trend of *E. coracana* in soils with treatments as compared to that which were in control set ups. Therefore, in this regard, plastic materials interfered with *E. coracana* seeds establishment thus leading to lower emergence.

Thick plastic material must have caused poor water infiltration in the soil thus leading to failure of maximum seeds germination of *E. coracana* and *Z. mays* in the experiment. Impermeability as a result of plastics probably caused water stagnation which in turn lead to poor soil aeration and hence reduced ability of most of *E. coracana* and *Z. mays* seeds to germinate. Moreover, the same property of plastic materials must have hindered water infiltration thus affecting adversely water absorption by seeds of *E. coracana* and *Z. mays*. This was not the case in plots with no plastic materials.

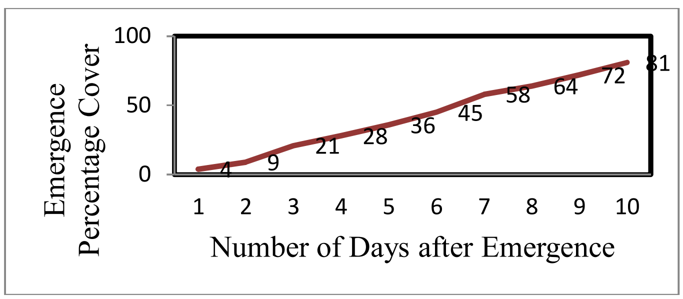
From the past research by Kirby [1], subsequent elongations of shoot of cereals such as barley have been found to be affected by compacted soils and hence mechanical impedance. This effect could be the same as that of thick plastic waste in the soil. As reported by William (1997), Carmichael [19], Aldred [20], plastics such as polythene contribute to poor soil aeration, and so it could be that thick plastic material brought the same effect thus leading to lower percentage crop ground cover of both *E. coracana* and *Z. mays*.

Mean while, poor soil drainage must have caused oxygen deficiency in the soil mixed with plastic material thereby leading to reduced geminative emergence of the two food crops. This therefore supports the study which was reported by Innocenti *et al.,* [21] that improperly drained soils have poor aeration and consequently affect crop establishment and growth. It could be possible that thick plastics caused poor soil aeration. This in turn slowed down the ability of shoots emerging from the soil unlike those which had been planted in soils without. The findings also supported the study which was carried out by Ellsworth *et al.,* (2003), on seedling emergence, growth, and allocation of oriental bittersweet that, forest floor litter (which can be compared with plastics) reduced the rate of seed emergence from the soil.

(a) Z. mays in plots without plastics
(b) Z. mays in plots with plastic materials



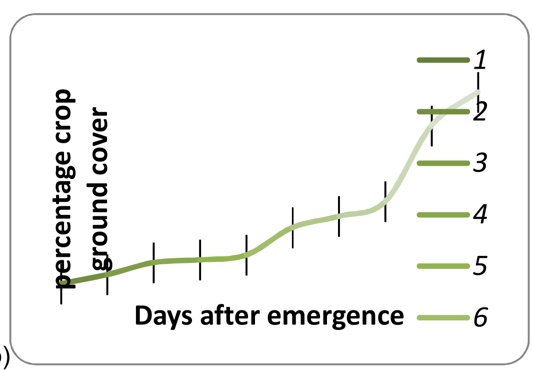
(a) *Z. mays* in plots without plastics



(b) *Z. mays* in plots with plastic materials

Fig. 1. Trend of *z. Mays* epc throughout the study period. N/b: vertical bars represent ± 1se (1 standard error)

b)



c)

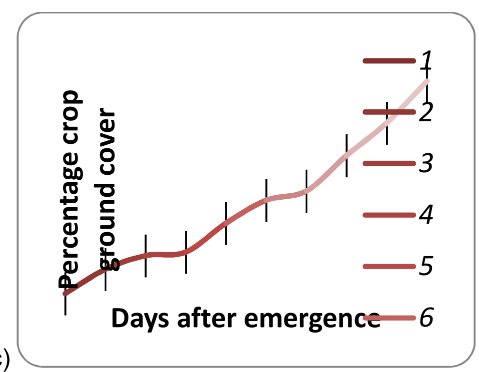


Fig. 2. Trend of *E. coracana* EPC throughout the study period. N/B: Vertical bars represent ± 1SE (1 Standard Error)
(b) E. coracana in plots with plastic materials, (c) E. coracana in plots without plastic materials (control)

Table 3. Overall epc mean of *e. Coracana* and *z. Mays* (for 10 days)

Z. mays					***E. coracana***			
Treatment	*Z. mays*	Control	±SE	Sig	*E. coracana*	Control	±SE	Sig
Thick plastics	41.52	86.18	±1.99*	0.002	25.78	75.58	±1.98*	00 .000

*ns: not significant and *: p≤ 0.05*

3.3 Overall Effect of Thick Plastic Material on Germinative Emergence of Z. mays and E. coracana

In the overall, plastic materials significantly brought effect on germinative emergence of *E. coracana* and *Z. mays*. Based on the results illustrated in Table 3, there were significant differences in *E. coracana* and *Z. mays* on their germinative emergence in soils with thick plastic material. It was observed that in all plots of soil mixed with thick plastics, *E. coracana* and *Z. mays* EPC mean were always lower as compared to those in their controls.

The results conform to the findings of Mostafavi *et al.,* [22], who also found out that physiological drought stress on germination indices of corn hybrids (*Zea mays* L.) impend their germination. Similarly, Gholamin and Khayatnezhad [23], state that polyethylene glycol adversely affects germination of *T. durum* and its early seedling stages especially due to their impermeability which in turn hinders water infiltration in the soil. According to Mohammad and Heidari, [24] water stress induced by polyethylene glycol 6000 and sodium chloride brought reduced rate of germination and so impedance of germinative emergence in the two corn cultivars.

These findings were similar to that which was carried out by Holt, 2000), in their study on germination and seedling growth of prairie grass. In their experiment, they found out that, weak shoots were not able to go through soils with non-decomposed plants litters and this can be compared to thick plastics in the soils where *Z. mays* and *E. coracana* were planted in the study. *Z. mays* and *E. coracana* in the study might have experienced physiological drought, as it is explained by Ajarmi [25]; Arndt [26], that inadequate moisture in the soil is one of the most important factors that limit the process of seed germination as well as their early growth and development.

4. CONCLUSIONS

Germinative emergence of *E. coracana* and *Z. mays* were significantly affected by plastic materials mixed in the soil and hence lead to reduced emergence percentage cover. Throughout the study time, there occurred a lower percentage ground crop cover trend on *Z. mays* and *E. coracana* in soils mixed with plastic material compared to that which did not have. The plastic materials significantly brought negative effect on germinative emergence of *E. coracana* and *Z. mays.*

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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